ANOTHER slight shock of earthquake was felt at Berne on the night of the 1st inst. Fresh earthquake shocks are reported from Agram, where shocks were observed on January 25 at 1h. 15m. (in the morning) 11h. a.m.; on the night of January 26 at 11h. 28m.; in the morning of January 31 at 3h.; on January 3 at 3h. (in the morning), 1h. 15m., and 4h. 13m. p.m. In the night of January 27-28 shocks were felt at St. Ivan, Zelina (Hungary) at 12h. 52m., 3h. 9m., 4h. 32m. On January 28 two shocks were felt at Gurkfeld (Carinthia) and neighbourhood at 8h. 50m. p.m., direction north-west to south-east. Earthquakes were also noticed on January 25 at Venice, Bologna, and Padua. In the night of January 3-4 shocks were observed in the regions of the Carinthian Alps, in Klagenfurt, at 2h. 22m. 25s., direction east to west, duration 5-6s.; in Trieste at 2h. 24m., direction north-east to south-west, duration about 4s.; at the same time shocks were felt in Laibach, in Gurkfeld, and in Czegled (Hungary).

AN examination has taken place at Brussels of the railway *employés*, in order to test their eyes. More than one-twentieth of them have been found defective, and consequently will be discharged as being unable to fulfil their functions with a sufficient security for travellers.

THE AURORA AND ELECTRIC STORM OF JANUARY 31

WE have received the following further communications on the recent brilliant display of aurora:—

THE beautiful display of aurora on the evening of Thursday was accompanied by the usual earth-current disturbances. They were evident over the whole of the United Kingdom. Telegraphic lines were stopped, railway block-signals were disturbed, and all the usual accompaniments of these curious storms were observed.

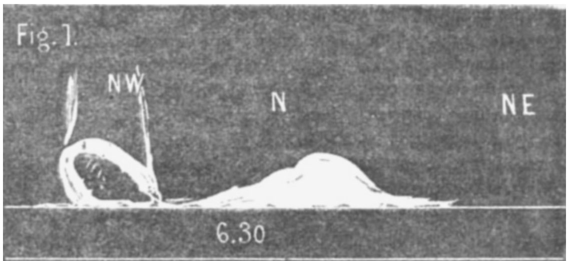
The electric storm commenced about 3 p.m., it reached a maximum at 6.40 p.m., and disappeared about 9 p.m. It was renewed about 11 p.m., and disappeared again about 1 a.m. on the next morning. The currents attained an intensity that I have never before observed. At Llanfair in Anglesey they measured 41·4 millivebers. At Haverfordwest 30 millivebers; at Bristol 17·32 millivebers; in the Central Station, London, 11 millivebers; at Edinburgh 8 millivebers. Now as working-currents vary from 5 to 10 millivebers, it is clear that these uninvited wanderers must play sad havoc with the working telegraphs. In some instances they were strong enough to ring the bells used on railways. They are eliminated, where this can be done, by joining two wires in *metallic circuit*, and so excluding the earth. They were characterised by the usual reversals, the direction of the current changing slowly. The changes in direction and variation in strength were always observed on the southern lines first. The line of maximum force commenced south-east to north-west, then passed south to north, and ended south-west to north-east.

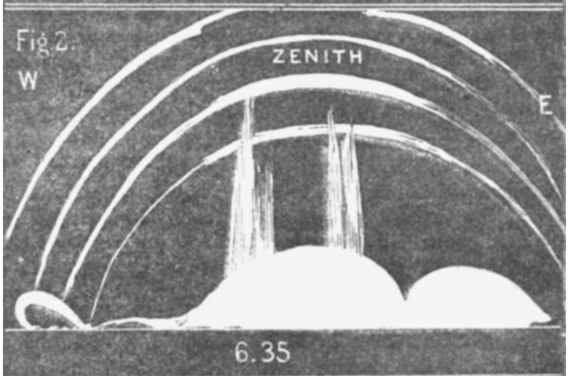
It is unfortunate that on such occasions the whole energies of the technical staff are taken up in maintaining communication, and that no time or means can be found to obtain accurate measurements. The results however, such as they were, fully confirm my view that these storms are due to a violent disturbance of the distribution of electric potential on the earth's surface arising from violent changes in the electrification of the sun. There was a violent disturbance in the sun's envelope on that day, as I learn from Mr. Norman Lockyer, and I am looking with interest to some particulars of it.

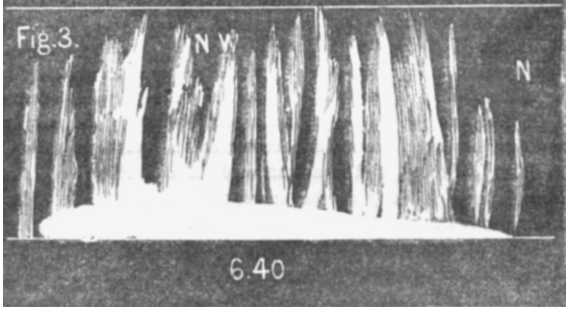
February 5 W. H. PREECE

ON yesterday evening, January 31, a most brilliant display of the aurora was seen here. It was by far the finest I have seen, and others have expressed the same opinion. At 6.25 p.m. I saw a considerable illumination on the northern horizon, and an outlying bright patch on the north-west having somewhat the appearance of the zodiacal light, as shown in the sketch, Fig. 1. This outlying patch was distinctly in motion along the horizon towards the west; streamers from the horizon then shot up, and there appeared several arches of light apparently about the width of an ordinary rainbow, passing from the north-west to north-east points on the horizon; these arches gradually approached the zenith, and the southernmost from the east and west points of the horizon at last passed through it. Some of these arches are shown in Fig. 2, but there were more visible. In a few minutes, about 6.40, the arches faded, and there appeared, rather west of north, a mass of bright green light; then the streamers from the north lengthened out, as shown in Fig. 3, converging on the Pleiades, as near as I could judge; waves of red light commenced to pass upwards along them, and large sheets of light appeared to pass rapidly over the sky. The streamers gradually died away, leaving flashing lights near the horizon, which in their turn left a slight light over the northern horizon, which gradually faded away. Mr. Percy Smith made the sketches, but owing to the rapid changes their accuracy is only general. Both he and I saw only one line in the spectrum in the usual place. GEORGE M. SEABROKE

Temple Observatory, Rugby, February 1







THE aurora observed during the evening of January 31 was accompanied by a magnetic perturbation, and although it was on a much smaller scale than that registered on August 12 to 14 last, a brief account of it may possess some slight interest to your readers.

The magnets of all three instruments at Kew, the declination, bifilar, and balance magnetometers, began to be disturbed to a somewhat larger extent than usual about noon on the 31st, the general tendency of the movement being an increase of westerly declination and of vertical force, whilst the horizontal force slightly diminished. Quicker movements of the needles commenced at 3.40 p.m. Greenwich mean time, and from that hour until 8.33 p.m. oscillations followed each other at short intervals, although the magnets at no time appeared to be in the state of rapid vibration they were in during the afternoon of August 12.

The principal deviations registered were as follows:—A large westerly deflection of the needle was recorded at 6.2 p.m., but the greatest excursion in that direction took place at 6.47 p.m.; at 7.12 p.m. there was also another considerable westerly movement, followed by an easterly, which reached its maximum at 7.48 p.m. At 8.18 p.m. it deviated again to the west, after which it returned to its approximately normal position at 8.33 p.m. An isolated deflection to the west at about 0.25 a.m. of February 1 wound up the storm.

As regards force, the greatest changes of horizontal force occurred at about 6 p.m., but they were not large in extent. The vertical force curve moved in the extent of an augmented force beyond the limits of registration of the instrument between 4.20 and 5.32 p.m., and again between 6.2 and 6.45 p.m. The greatest movement in the direction of diminished force was at 8.12 p.m.

The self-registering Thomson electrometer was not apparently affected by the aurora; the tension of atmospheric electricity being somewhat high positive at 9 a.m., fell to a low positive tension at 2 p.m., from which it rose gradually, although somewhat irregularly, until 8 p.m.; from that hour until 9 p.m. it was more disturbed; it then became more strongly positive, and remained so until the next day.

This want of accordance between the electrograph and magnetographs was also well marked during the August aurora, and would appear to prove that the electrical disturbances in the upper aërial strata during aurora do not cause changes of tension in the lower at all commensurable with those ordinarily produced by wind, snow, or rain. G. M. WHIPPLE

Kew Observatory, February 2

THE commencement of the aurora consisted in the sudden lighting up of various portions of the sky by patches of white cloud, the northern horizon remaining constantly bright, and sending forth vertical streamers. The general appearance of the heavens was that of a smooth lake ruffled here and there every other second by fitful gusts of wind.

At 6.45 p.m. no ordinary clouds could be seen, but the flashes of white light were incessant, and varied continually in position. The light was strongest towards the north-east horizon, but the whole of the north was well lit up from north-east to west.

At 6.50 the streamers from the horizon increased in length and enveloped Polaris.

At 6.55 the number of the streamers increased, and springing from the whole northern horizon, traversed an imperfect arch of white light which passed between ε and ζ Ursæ, and just below β and γ Ursæ Minoris.

At 6.57 streamers 10° west of north passed from the horizon through the zenith, and the display was becoming very brilliant when I was obliged to enter the observatory for a few minutes to observe an eclipse of Jupiter's second satellite.

On returning to the garden at 7h. 5m. nothing remained of the aurora except patches of white light in different parts of the heavens, and a strong glow in the north. Using a hand spectroscope I could see the green auroral line very strongly marked in every part of the sky, but no other line was visible.

There was no change in the phenomenon until 7h. 45m., when a most brilliant cone of light of a reddish hue darted from between α and γ Aquarii, and developed almost immediately into a number of streamers which stretched out towards the Pleiades, this cluster being then some 30° from the zenith towards the west of south. Other streamers also appeared near the horizon from the west point to east of north.

A lull succeeded this display, followed at 8h. 15m. by a grand outburst of red streamers from Aquarius and also from near Orion, both converging towards the Pleiades, those from Aquarius being the brightest. These were visible for at least six seconds along with other rays in the north-west.

Cloud and haze were then collecting fast, and seven-tenths of the sky was already obscured. During this aurora the three self-recording magnets were very much disturbed, their movements being all rapid and extended. During the whole of the morning of the 31st the declination was very irregular, but it was only about noon that the storm began in earnest. From 3.30 until 9 p.m. the declination magnet was oscillating incessantly in long vibrations, several of fully a degree in extent; and between 7h. 53m. and 8 p.m. the western bearing increased by 1° 37′ 24″. Many other movements were nearly equally rapid, but not so extensive. The movements of the horizontal force magnet were irregular from noon till after midnight, and they were very much exaggerated between 3h. 45m. p.m. and 8.15; the most rapid change was the remarkable diminution of 2·1 in. in the ordinate between 6.14 and 6.20 p.m.; this was preceded by a very quick rise, and followed by another nearly equally sharp.

The vertical force magnet was most irregular between 2 p.m. on the 31st and 1 a.m. on the morning of the 1st. The extreme maximum was attained at 4h. 20m., and the two principal minima at 8h. 12m. p.m., and at 12m. after midnight. The movement was most rapid at 8 p.m., and this principal disturbance on all the curves coincided with the grand outbursts of red streamers which converged towards a point some 30° south of the zenith.

Stonyhurst Observatory, February S. J. PERRY

MR. E. DOWLEN has been again good enough to furnish me with notes on the aurora (of Monday last), as seen from Medway, Poynton, Cheshire.

He first saw it at 6.30, it having been previously seen at 6 as a single shaft of white light. At 6.30 it consisted of quickly-darting rays and waving curtains of light, filling almost the whole sky. The horizon from extreme east to west was glowing, and from all this region streamers and waves of light shot upwards, meeting at or near the Pleiades, the rays often passing into Orion. About 7.0 the light in the north-west extending from Venus to some distance north of the moon was rose-coloured; the other parts were white. Now for a few minutes the display almost ceased and clouds began to come up in the north-east; but the glow increased in brilliancy in the north and north-west, forming a concave mass of light, almost an inverted arch; and from this sprang a broad band of streamers filling up all the northern region, and reaching almost to the zenith. This died down, and was succeeded by a similar display having a drifting movement westward, and a rose tint in the upper portion, which extended throughout it as it went westward. This display also died out, and was followed by another similar band more to the west, white in colour.

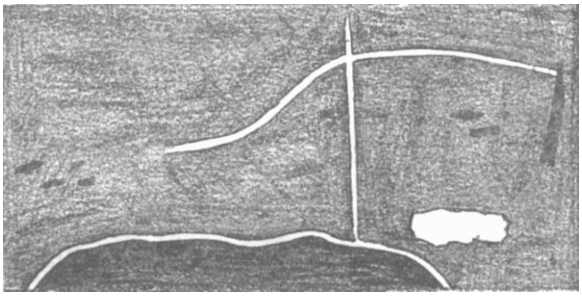
At 7.30 this was gone, and the whole aurora gradually grew smaller, the glow still remaining and giving feeble spurts until 8.30. About 9.30 the clouds were all gone, and Mr. Dowlen saw that a long low arch of inconsiderable width but tolerable brightness had been formed; the crown of the arch being just above Arided in Cygnus. No streamers came from this arch, but there seemed to be a fringe of glow to it. At midnight it faded away. During the whole time there was no wind; and although there was a ground-frost, the temperature up to 9 o'clock, by thermometer without frame suspended at the end of a bough four feet from the ground, was 34°. At 5 p.m. there had been a sharp shower of rain. Mr. Dowlen had no access to a spectroscope at the beginning. Later on he saw only the citron line.

At Guildown the display was not seen, and some fog prevailed. On the Monday morning at 8 a.m. a thermometer read 35° in a Stevenson cage four feet from the ground, while ice one-eighth of an inch thick lay on the garden paths.

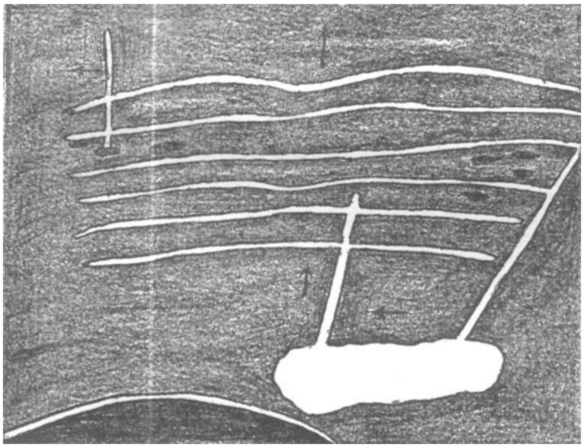
The shower of rain is interesting in connection with the suspicion that the aurora is generally formed in a mist or vapour region. I have seen several eye-descriptions of this aurora, but no spectroscopic ones up to the present date.

Guildown, February 4 J. RAND CAPRON

THIS was a display of aurora borealis having appearances quite new to me. There was a faint auroral glare at 6 p.m.; at 6h. 15m. a confused but brilliant mass of light was situated west of Ursa Major, which moved quickly horizontally towards the west, there was also another mass of pink light in west, streamers shot up to the altitude of Cassiopeia. 6h. 24m. the first-mentioned mass of light was now mostly to the west of Cassiopeia. There was also another mass of light low down in north by east. Stars shone brightly through the aurora, but without scintillation, and somewhat orange-coloured. 6h. 25m. brilliant streamers in north-east, a wavy arch stretched from west-north-west to east, its east end terminating in a black, almost perpendicular mass. There were also smaller black patches but quite distinct in character to the first-mentioned one. The low dark segment had also a wavy edge, and there was a patch of strong light above the north-east horizon. One very long streamer nearly due north rose from the dark segment and extended beyond the upper arch. At 6h. 27m. there were six well-formed arches, the upper one being that visible at 6h. 25m. They were all bent more or less, pointed towards east and west, and moved in a north current, *i.e.* rising perpendicularly; and increasing rapidly in speed as they neared the zenith, and fading away on reaching a point some 20° S. (of the zenith). Their brilliancy was great, and a strong orange and red glare coloured the walls of the Observatory. A large intense patch of light was situated in north-east, from which streamers rose to the zenith; at 6h. 28m. the whole of the arches (except that of the dark segment) had disappeared, occasional streamers and a strong glare continued, which at 7h. 9m. was unusually brilliant, and red and orange in colour. There were confused patchy lights, but no streamers. At 7h. 10m. these patches, together with their veil-like flames, passed to the south of the zenith, and formed a cupola which did not last a second; 7h. 16m. the phenomenon was now all confusion, and so thin that there appeared to be no brilliancy, yet the time by a watch was readily seen; 7h. 26m. very similar; 7h. 39m. still very bright, but settling down to the horizon; 8h. 34m. the whole northern heavens up to the zenith was a glare of thin sheets of aurora; 9h. 0m. a glare alone remained.



Seen at 6h. 25m. p.m.



Seen at 6h. 27m. p.m.

The streamers west of north all moved westerly, but not those in north-east, and this also applies to the patches of light, whilst the arches moved in a north current.

The appearance was that of a luminous mist, and from the great speed when near the zenith was evidently much lower than usual. Flashes of thin light were very constant, appearing and disappearing incessantly.

The patches of light were a close copy of the aurora of October 1848, *i.e.* thirty-two years three and a half months ago, and if this be the third return of that appearance the period would be eleven years and thirty-five days.

E. J. LOWE

Highfield House, Nottingham

AURORIC lights have been faint and scarce of late. There were some good ones a little before midnight on January 16, while on the 31st there was a most brilliant display, and of the observations made the following is an epitome:—

At 6 o'clock the sky was cloud-masked, with faint traces of orange-red columns between the north-west and north-east; coming up to 6.30 the clouds cleared away, and about 7 there were brilliant white lights to the north-west, making the night as light as day. At 7.40 an oblique band of silver light extended from the west to the upper star of the Plough, and from it shot up horns towards the zenith, while the southern portion of the sky was a fiery red, with columns rising in places. At 7.48 there were remarkable silver lights in two oblique systems, one set rising between the south and west and going northward, and the other between the west and north-east and going southward. The first were steady and fairly constant, the second a series of rapid successive flashes, streaks, and glows. The systems of lights formed beautiful crosses at the zenith. The flush lights passed round to the east, and all disappeared.

At 7.53 fans of pencils of silver lights came up between the north-north west and north-north-east, with at times disks at the north. Red, orange, and purple lights were rising at the same time in the southern portion of the heavens. Subsequently the northward heavens usually were light and bright, with flushes of light at intervals, while the southern portion was dark, with columns of orange and reddish lights; some displays to the northward being very bright, of green, silver, and pink colours.

At 9.30 there appeared an elliptic arch of silver light from the west-north-west by north to the north-east, which continued to 10.50, sometimes being much more distinct than at other times, its length being considerably contracted before it finally disappeared; the arch in general was white, but sometimes a silvery green. The under-sky was different shades of violet, the over-sky pale bright yellowish green. At times this arch was very similar to the pictures of auroræ given in books on Arctic travels.

At 10.45, a little before the arch finally disappeared, a brilliant display of silver pencils instantaneously sprang up between west-north-west and north-north-east; those at the north-north-west by north being perpendicular, while those on either side sloped slightly; this lasted for nearly ten minutes; glow and pencils of pink lights were also coming up during the time, especially at the north-west. Afterwards white lights appeared at times in the north heavens, and orange and purple in the south, up to 11.45, when there was another brilliant display of silver lights. It began by pencils shooting up perpendicularly between the west to the north-east, which changed into a fan, the perpendicular lights only rising at the north-north-west; this lasted five minutes, the largest, most constant, and brilliant lights coming up at the north-west. At 12 there was the best display I had seen during the night. It consisted of pencils between the north-west and north-north-east, some perpendicular, others fan-shaped; some steady, others in flashes; while at the same time there was a continuous upward stream of waves or lines of vivid white bright lights. The latter were so peculiar that I am at a loss to describe them sufficiently; while this display was in progress at the north, to the south-east, bounded by hard lines at the east and south, there were red lights rising. The white lights in about five minutes disappeared as suddenly as they came, but at 12.10 horizontal wavy white lights shot up in rapid succession between the north-west and north-north-east by north, followed by radiating pencils of white lights, all disappearing at 12.15. No very remarkable lights appeared afterwards up to 1 o'clock, when the last observations were made.

There were severe frosts on the nights of the 30 and 31st, while during the daytime on the 31st and February 1 there were remarkably hot suns.

G. HENRY KINAHAN

Ovoca, co. Wicklow

CLEAR starry night; slight frost. Shortly before 12 midnight beautiful auroras, when first observed, consisted of cloud-like white masses extending from about midway between Orion's belt and the Pleiades northward and eastward at about 30° above horizon, a little west of north, where the crown of the arc it formed lay below this arch of cloud-like masses (which at intervals shot up individually to the zenith); there were a number of pencils or rays of white light of varying length and intensity, some bright and sharply defined, and as a rule narrow and extending up to or beyond the cloud-like masses; others short, and some indistinct, all continually altering their position, boundaries, and intensities. While they were being watched, the cloud-like masses kept shooting upwards or horizontally like brush discharges.

Narrow sharply-defined rays were remarked to shoot up on several occasions from the horizon; these gradually widened out, losing their sharp boundaries and becoming less distinct, some times behaving like the cloud-like masses or becoming intensified by a "brush discharge" occurring across them; at others they faded gradually away.

At about 12.30 they had all disappeared, but a bright glow to the north horizon and faint glows at intervals over the sky between north and west.

It was not observed how far the discharges extended eastward.

24, Waterloo Road, Dublin GERARD A. KINAHAN

THE following details of this evening's remarkable aurora may be of interest to your readers. At 6.45 p.m., while the new moon was setting, there was an appearance of a belt of luminous white cloud reaching along the northern and north-western horizon, giving indications of a tendency to divide into two separate parts, of which the western one had its upper surface parallel with the horizon, but that to the north was arched. From both parts rays and vertical bands of white light began to shoot upwards, reaching nearly to the zenith, and becoming more and more distinct, especially in the north (as opposed to the north-west), and one long feathery streamer was very conspicuous, and reached in a slanting direction from a point on the horizon immediately under the Pole Star up to Capella.

In the meantime the cloud-like appearance to the north-west had spread upwards over the heavens and assumed a dark ruddy colour, which gradually became brighter and more rosy, until it exactly resembled the light of dawn or sunset, which is sometimes reflected on the opposite side of the sky to the rising or setting sun. At this time the northern heavens became suffused with white light extending over the space where the bands and rays had been appearing, which throbbed repeatedly and vividly like the electric discharge in a vacuum tube, continuing some minutes. This gradually faded away, and the pink light to the north-west also disappeared by degrees, so that within twenty or twenty-five minutes from the commencement (say at about five or ten minutes past seven) there was little to be seen but a hardly noticeable light along the north horizon. F. HORNER

Mells Park, Somerset, January 31

IT may interest your readers to know that the aurora of January 31 was distinctly seen by me here at about seven o'clock on that evening. Such a sight is so uncommon in this part of London that I had some difficulty in convincing my friends that it was the *aurora*. As I walked down the Wickham Road, Brockley, towards Greenwich, broad bands of light shot up from the northern regions and reached nearly to the zenith. Descending amongst the fog and smoke that overhung the lower parts of New Cross, the light gradually faded, and I saw no more of it.

W. J. SPRATLING

Aske's Hatcham Schools, Hatcham, February 4

THE aurora of January 31 was well seen here. It was at its brightest at 6.40 p.m. It extended from about north-west to nearly east. In the north-west and to the north of the crescent moon there was a large irregularly shaped patch of *greenish* phosphorescent light. Then round from it towards the north rose *crimson* streamers towards the zenith. The streamers continued round to the east nearly, still ascending zenithward, but white rather than crimson, between north-east and east. The streamers changed every instant, but the large greenish patch of light in the north-west was steady for some minutes.

It would be interesting to know whether observers in America noticed any unusual solar activity at the same absolute time as the aurora was occurring here, and also whether the magnetic elements in both hemispheres (north and south) showed disturbances in sympathy. D. TRAILL

Raleigh Lodge, Exmouth, February 4

GAS AND ELECTRICITY AS HEATING AGENTS[1]

II.

GAS engineers have been under the impression until now that a supply of cold air was favourable to the production of a brilliant flame. This is a misconception, which was very general also as regards the combustion of solid fuel in furnaces, until it was disproved by Stirling, by Neilson, and by the introduction of the Regenerative Gas Furnace. The "duplex burner" owes its brilliancy to the heating effect of the one burner upon the other; and my brother, Mr. Frederick Siemens, has more recently constructed a burner in which the flame of the gas is reversed in its action in order to heat in its descent the ascending current of flame-supporting air.

By the application of the principle of conduction before described, I obtain the hot-air current in a most simple manner without interfering with the free action of the flame. The construction of my burner will be seen from the diagram. A is an ordinary Argand burner, taking its supply of gas through the enlarged vertical copper tube B. This copper pipe terminates in a rod C of highly conductive copper, which passes upward through the burner, and carries at its top a ball of porcelain or other refractory material. The rod is coated with platinum or nickel to prevent oxidation when heated (almost to redness) by the heat of the flame. The tube B is armed with radial plates of copper presenting a considerable aggregate surface, and abutting externally against a covering of asbestos or other non-conductive material.

The waste heat of the flame, or that portion of the heat produced in combustion which is not utilised in luminous rays, serves to heat the ball of refractory material D and the conductive rod C. The heat is thus transferred by conduction to the tube B, with its laminar radii, between the extensive surfaces of which currents of air are free to ascend toward the Argand burner. The air is thus heated to from 700° to 800° F. before meeting the gas, and the ultimate temperature of the flame is increased to at least the same amount, causing a larger proportion of the heat developed in combustion to reach the point of luminous radiation.

But not only the quantity of light but its quality is improved by the higher temperature obtained.

It may appear surprising, but it is a fact susceptible of accurate proof, that the light obtained in consumption of a given amount of gas may thus be increased by some 40 per cent., and that in this large proportion the deleterious influences connected with gas lighting may be diminished. Gas will thus be better able to hold its position against its more brilliant rival the electric light, except for such large applications as the lighting of public halls and places, of harbours, railway stations, warehouses, &c., for which it is pre-eminently suited. Add to these improved applications of gas the ever-increasing ones for heating purposes, and I have only to express regret that I am not a gas shareholder.

If gas is to be largely employed, however, for heating purposes, it will have to come down in price; and considering that heating gas need not be highly purified, or possessed of high illuminating power, the time will come, I believe, when we shall have two services, one for illuminating, and the other for heating gas.

In many towns two systems of gas mains already exist; and it would only be necessary to appropriate the one for illuminating and the other for heating gas. The ordinary retorts could be used for the production of both descriptions of gas, it being well known that even ordinary coal will give up gases of high illuminating power during a certain portion of the time occupied in their entire distillation. The gases emitted from the retort when first charged are to a great extent occluded gases of low illuminating power such as fire-damp or marsh-gas, and these should be turned into the heating mains. In the course of half-an-hour these occluded gases, together with the aqueous and other vapours, will have left the coal, which is then in the best condition to evolve olefiant gas and other gases rich in carbon, and therefore of high illuminating power. The period during which such illuminating gases are emitted extends over probably two hours, after which the retorts should again be connected with the heating gas mains, until the end of the process. The result of this *modus operandi* would be that the illuminating gas supplied, say in London, from Newcastle coal would probably exceed 20 candle power, instead of 16 as at present, whereby the objectionable results of gas lighting would be greatly diminished, and there would be, say, an equal volume of heating gas available, consisting for the most part of marsh-gas, which, although greatly inferior to olefiant gas in illuminating effect, would be actually more suitable for heating purposes, because less liable to produce soot in its combustion.

The total cost of production would not be increased by this separation of the gases, and the price might with advantage

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[1] A lecture by C. William Siemens, D.C.L., LL.D., F.R.S., on January 27, in St. Andrew's Hall, Glasgow, under the auspices of the Glasgow Science Lecture Association. Continued from p. 329.